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∴ of  $R$ ,  $\{-[\frac{1}{2}(s-a) + \frac{1}{2}(s-c)\cos B], -\frac{1}{2}(s-c)\sin B\}$ ;

of  $Q$ ,  $\{\frac{1}{2}[s+a+(s-b)\cos C], -\frac{1}{2}(s-b)\sin C\}$ ;

of  $P$ ,  $\{\frac{1}{2}[s(\cos C + \cos B) - a], \frac{1}{2}s(\sin C + \sin B)\}$ .

$BH = r \cot \frac{1}{2}B$ ,  $OH = r$ ,  $bE = x$ ,  $BE = x \cot \frac{1}{2}B$ .

∴  $(r-x)^2 \cot^2 \frac{1}{2}B + (r-x)^2 = (r+x)^2$ . ∴  $x = r(1 - \sin \frac{1}{2}B)/(1 + \sin \frac{1}{2}B)$ .

Let  $r(1 - \sin \frac{1}{2}B)/(1 + \sin \frac{1}{2}B) = m$ ,  $r(1 - \sin \frac{1}{2}C)/(1 + \sin \frac{1}{2}C) = n$ ,  $r(1 - \sin \frac{1}{2}A)/(1 + \sin \frac{1}{2}A) = l$ .

∴ coördinates of  $b$  are  $(m \cot \frac{1}{2}B, m)$ ; of  $c$ ,  $(a - n \cot \frac{1}{2}C, n)$ ; of  $a$ ,  $(p \cos aBC, p \sin aBC)$ , where  $p = \sqrt{[c^2 - 2cl \cot \frac{1}{2}B + l^2 \operatorname{cosec}^2 \frac{1}{2}A]}$ , and  $\tan aAB = (c \tan B - l \tan B \cot \frac{1}{2}A - l)/(c - l \cot \frac{1}{2}A + l \tan B)$ .

Substituting in (1) and (2) the truth of the proposition appears.

By substituting the coördinates of  $P$ ,  $Q$ ,  $R$ , and  $a$ ,  $b$ ,  $c$  in (1), (2) we get, after a prodigious amount of work, the coördinates of two points. If the line through these two points coincides with the line through  $O$ ,  $M$ , the proposition is true.

[NOTE.—Dr. Zerr furnished a very beautiful figure to go with his solution, but we lacked the time to engrave it. EDITOR.]

83. Proposed by WILLIAM HOOVER, A. M., Ph. D., Professor of Mathematics and Astronomy in Ohio University, Athens, O.

$\theta$  being variable, find the locus of a point whose coördinates are  
 $a \tan(\theta + \alpha)$ ,  $b \tan(\theta + \beta)$ .

Solution by the PROPOSER.

The rectilinear coördinates being  $x$  and  $y$ ,  $x = a \tan(\theta + \alpha) \dots \dots \dots (1)$ ,  
 $y = b \tan(\theta + \beta) \dots \dots \dots (2)$ . (1) gives  $\theta + \alpha = \tan^{-1}(x/a) \dots \dots \dots (3)$ ,  
 $\theta + \beta = \tan^{-1}(y/b) \dots \dots (4)$ . Eliminating  $\theta$ ,  $\tan^{-1}(x/a) - \tan^{-1}(y/b) = \alpha - \beta \dots (5)$ .

Taking tangents of both members of (5) and reducing,

$$xy - \cot(\alpha - \beta)(bx - ay) + ab = 0 \dots \dots \dots (6),$$

the equation to the required locus.

Solved in a similar manner by COOPER D. SCHMITT, T. W. PALMER, OTTO CLAYTON, and G. B. M. ZERR.

## CALCULUS.

65. Proposed by GEORGE LILLEY, Ph. D., LL. D., Professor of Mathematics, State University, Eugene, Ore.

A string is wound spirally 100 times around a cone 100 feet high and 2 feet in diameter at the base. Through what distance will a duck swim in unwinding the string keeping it taut at all times, the cone standing on its base and at right angles to the surface of the water?